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(54) **High ratio pressure-reducing valve**

(57) A high ratio pressure-reducing valve comprises a high pressure fluid conduit means 11 including an outlet portion 22 and a fluid flow restrictor 25 in direct fluid communication with the outlet portion. The fluid flow restrictor is provided with a valve plug 36 which is operable to close the fluid flow restrictor to fluid flow. A balancing element 39 is associated with the valve plug 36 and disposed within the conduit means such that a surface of the balancing element is exposed to the high pressure fluid whereby the balancing element tends to negate the high fluid pressure effects on the valve plug, thereby confining high pressure effects to within the conduit means.

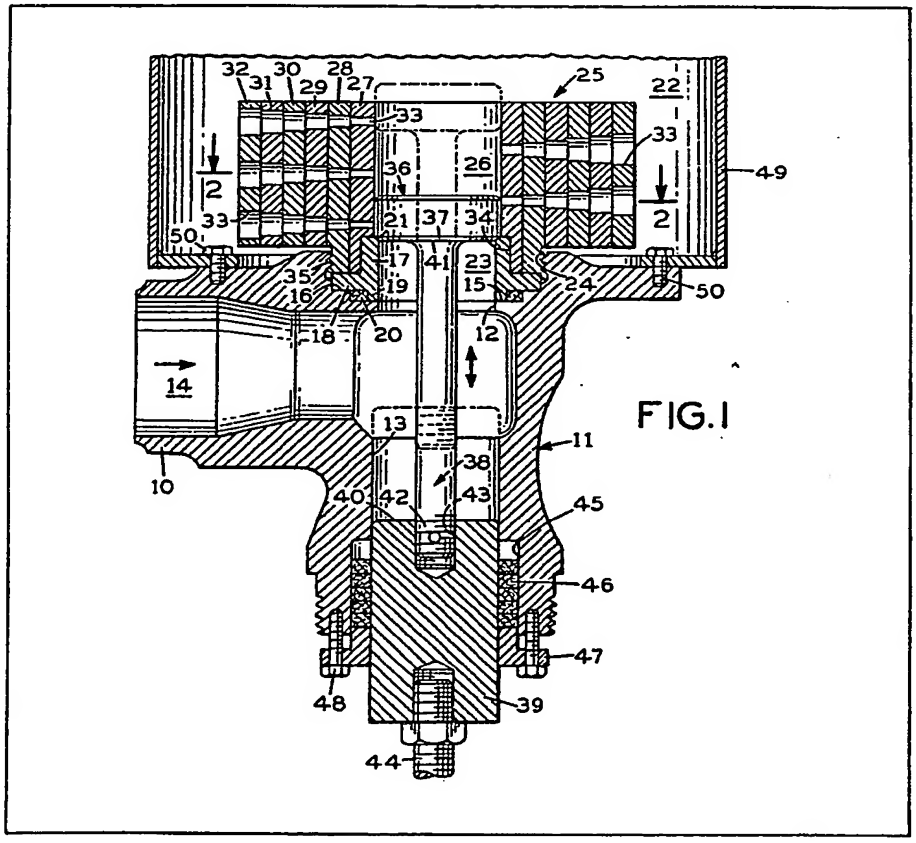

FIG.1

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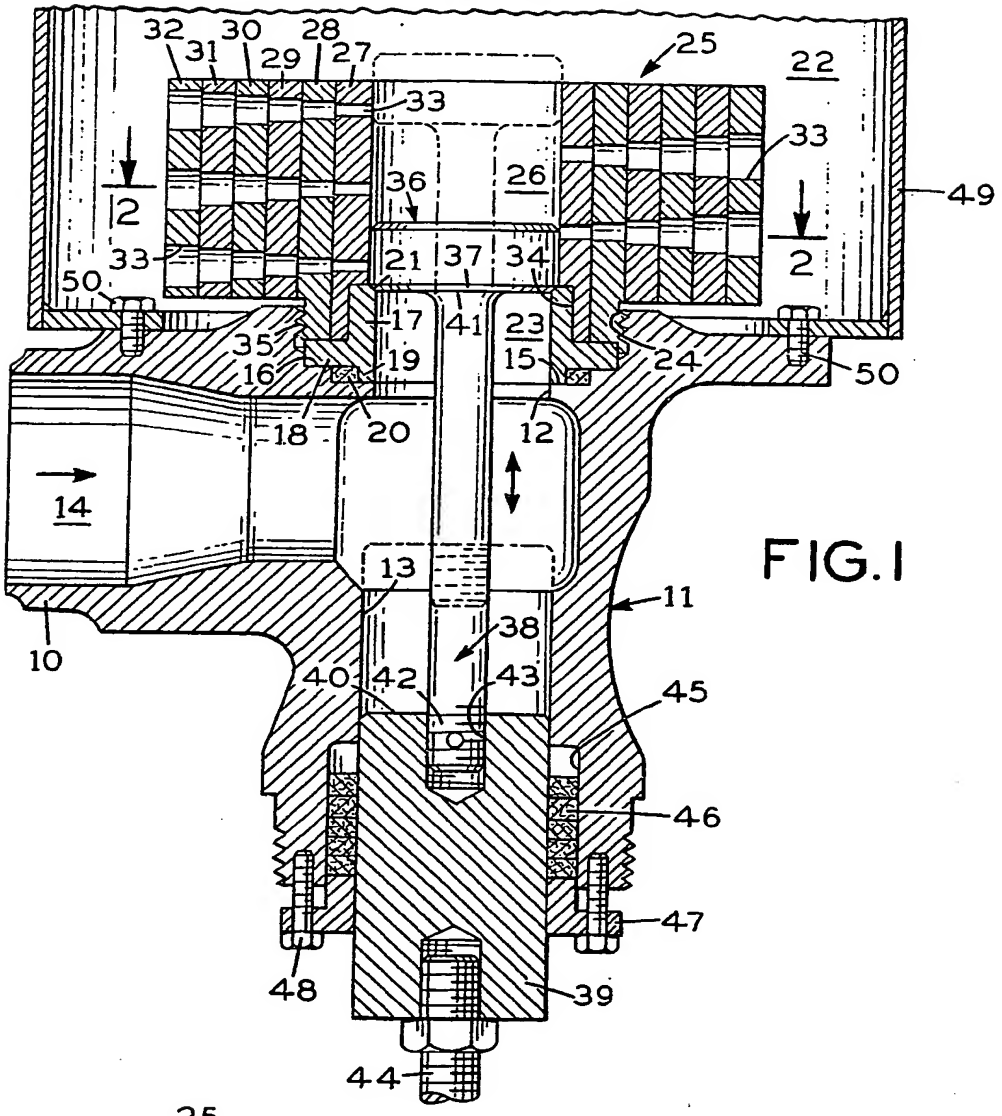
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FIG.1

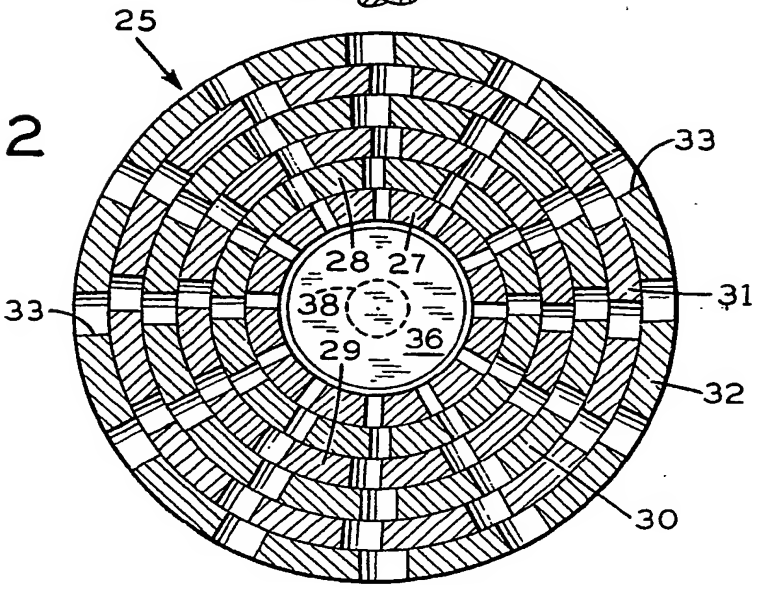
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FIG.2

SPECIFICATION

High ratio pressure reducing valve

The present invention relates generally to a high ratio pressure reducing valve and in particular provides a valve structure wherein a fluid flow restrictor is mounted outside the valve body such that the use of high strength, heavy wall construction is required only in the areas of the valve forming the annulus around the valve stem and the fluid inlet port.

In the handling of high pressure fluid flow it is often necessary to provide an economical, safe means for permitting a high pressure drop in the fluid flow. Typically, high ratio pressure reductions are necessary in the operation of power-operated relief valves wherein high pressure steam, for example, from a boiler system is vented to a low pressure condenser or to the atmosphere. Heretofore known means for venting high pressure fluid to the atmosphere or to a low pressure outlet include arrangements such as valves with low pressure drops and a silencer or noise attenuating devices connected to the outlets thereof. Valves provided with a series of downstream pressure-reducing orifice plates have also been used, as well as valve structures incorporating fluid flow restrictor devices.

While the above-mentioned prior art devices have been somewhat effective in their intended use, there are drawbacks associated with each one. For example, the state of the art for fluid flow restrictor devices (e.g., of the stacked disc type) is such that these devices are superior in noise attenuation and fluid energy dissipation than the silencers attachable to standard valves. However, the fluid flow restrictor devices are generally mounted within a web portion of a valve body and disposed between the inlet and outlet portions of the body. In the high pressure drop application contemplated by the present invention, an eight-inch inlet pipe would require a valve body with an outlet having a diameter of between 20 to 40 inches. Such a large diameter outlet requirement would result in a very bulky, expensive valve structure. And, of course, utilizing a standard valve-silencer combination necessarily sacrifices the more favorable operating characteristics of a fluid flow restrictor device.

In one prior art proposal, the Self U.S. Patent No. 4,068,683, for example, a stacked plate fluid flow restrictor is mounted on a plate integrally formed with a fluid inlet pipe. The restrictor stack includes a central, cylindrical inlet chamber which overlies the open end of the inlet pipe whereby fluid flows from the pipe into and through the restrictor to the atmosphere. An axially movable valve plug is received within the chamber such that the stack may be partially exposed to fluid flow or the flow may be interrupted completely. While the Self arrangement utilizes a fluid flow restrictor without the need of a large valve body, the high pressure stream on the upstream side of the device exerts considerable pressure on the valve plug tending to place high forces on the plug stem. To ameliorate the stem force problem, the Self proposal provides axially extending passageways in the valve plug, whereby high pressure steam may flow above the plug and flow restrictor to balance the forces acting on the valve plug and stem. However, this places a high pressure force above the restrictor, requiring a heavy, rigid construction for the components fastening the flow restrictor to the mounting plate, thereby increasing the weight, cost and complexity of the device.

It is a primary objective of the present invention to provide a valve device incorporating a fluid flow restrictor with a balanced valve plug and without the requirement of heavy duty construction in areas other than the high pressure fluid inlet portions of the device. In its broadest aspects, the valve of the present invention comprises a high pressure fluid inlet means with an open end and means to attach a fluid flow restrictor device to the inlet means whereby the inlet portion of the restrictor device is in fluid communication with the open end of the high pressure inlet. An axially movable valve plug is received within the flow restrictor device and is movable by an operating stem which is connected to the plug and extends therefrom on the upstream, high pressure side of the valve. A valve seat is formed intermediate the fluid flow restrictor and the open end of the inlet means, whereby the valve plug can mate therewith to close the valve. When the stem is operated to lift the plug from the valve seat, high pressure fluid from the inlet means will flow directly into and through the flow restrictor device such that the device will subject the fluid flow to a controlled, gradual energy dissipation to atmospheric pressures. The fluid may then be exhausted directly from the restrictor device to the atmosphere or to a low pressure component.

Pursuant to an important aspect of the invention, a balancing element is associated with the valve stem and includes a portion having a cross-sectional area in an opposed, spaced relation to the upstream, high pressure side of the valve plug. The cross-sectional areas of each of the balancing element and the upstream side of the valve plug are matched whereby high pressure fluid from the inlet means will act evenly on each of the surfaces to thereby substantially eliminate unbalanced fluid forces acting upon the stem, valve plug or areas outside the fluid flow restrictor or high pressure inlet means.

To considerable advantage, the valve of the present invention effectively confines high pressure forces to within the inlet means, eliminating the need for a bulky, heavy construction for the remaining components of the valve. For example, the above-described valve structure will greatly simplify the means for connecting the fluid flow restrictor to the inlet pipe. It will not now be necessary to provide heavy reinforcing structures to hold the restrictor against the high pressures of the upstream fluid. Moreover, the balanced valve plug will facilitate smooth, easy operation of the valve stem to

provide a dependable, convenient valve action. The output of the fluid flow restrictor device may be opened directly to the atmosphere thereby providing a high ratio pressure reducing valve utilizing the advanced technology of a fluid flow restrictor device in a streamline structure.

For a more complete understanding of the above and other features and advantages of the invention, reference should be made to the following detailed description of a preferred embodiment of the invention and to the accompanying drawings.

Fig. 1 is a side cross-sectional view of a high ratio, pressure-reducing valve built in accordance with the principles of the invention.

Fig. 2 is a cross-sectional view of the fluid flow restrictor portion of the new valve, taken generally along line 2—2 of Fig. 1.

Referring now to the drawings and initially to Fig. 1 thereof, the reference numeral 10 designates a high pressure fluid flow inlet. Integral therewith is a valve body 11 including opposed, spaced passageway openings 12, 13. The openings 12, 13 are each in communication with the passage 14 of the inlet 10 and are disposed in a generally perpendicular relation to the central, longitudinal axis of the inlet 10.

In the illustrated form of the invention, the passageway opening 12 is formed to include concentric, circular lands 15, 16. A hollow cylindrical sleeve 17 provided with a circular, radially-extending flange 18 is snugly received within the passageway opening 12 such that the circular flange 18 rests on the land 16 and the internal wall of the sleeve 17 forms a continuation of the sides of the opening 12. Moreover, an integral cylindrical extension 19 of the sleeve 17 extends into contacting relation with a portion of the land 15. Packing material 20 is tightly received between the land 15, flange 18 and extension 19 to provide a leak-tight seal between the outside of the sleeve 17 and the interior of the passageway opening 12.

A tapered surface 21 is formed along the inner perimeter of the open top of the sleeve 17 to define a valve seat. The portions of the valve body extending from the land 16 and surrounding the sleeve 17 are formed to provide an internal thread 24. In this manner, the arrangement of passageway opening 12 and sleeve 17 described above provides a fluid outlet passage 23 from the valve inlet 10 to the atmosphere 22. The threaded section 24 is in a concentric, spaced relation to the sleeve 17 to accommodate simplified attachment of a fluid flow restrictor device, as will appear.

In Fig. 1, the reference numeral 25 generally designates a fluid flow restrictor, including a central fluid inlet chamber 26, arranged to overlie the sleeve 17 such that the chamber 26 is in fluid communication with the fluid passage 23. To advantage, the fluid flow restrictor 25 comprises a series of close-fitting, concentric cylinders 27—32 which are rigidly fastened together, as for example, by welded joints. Each of the cylinders 27—32 includes a plurality of radially disposed openings 33 spaced across the surface thereof and extending through the particular cylinder with a uniform diameter.

As can be clearly seen in Fig. 2, the concentric cylinders 27—32 are arranged and configured whereby each opening 33 of each cylinder overlaps at least one opening 33 of each contiguous cylinder to form restricting orifices between the overlapping openings 33. Moreover, each opening 33 is sufficiently large to provide an expansion chamber for fluid flowing therethrough. Accordingly, as will be described in greater detail hereinafter, high pressure fluid, for example steam, flowing through the valve will flow through the passage 23, into the input chamber 26, and then subdivide into separate streams passing through the openings 33. The individual streams will each undergo a gradual, controlled energy dissipation by passing through the series of expansion chambers and restricting orifices defined by the overlapping openings 33.

To advantage, the diameter of the openings 33 may be arranged to progressively increase in the downstream direction to accommodate expansion of compressible fluids, such as steam. Typically, the dimensions of each opening 33, the degree of overlap therebetween and the number of cylinders may be predetermined with great mathematical accuracy, so that the pressure of the steam passing from the outermost, downstream cylinder 32 of the fluid flow restrictor 25 will have been sufficiently reduced for safe, direct exhaust of the steam to the atmosphere 22.

For a more detailed description of a fluid flow restrictor of the type described above, reference should be made to British Application No. 31822/78 filed August 1, 1978. Of course, it should be noted that the present invention is not limited to use in connection with a fluid flow restrictor of the type disclosed in the aforementioned British application. However, it is considered preferable to utilize such a restrictor herein.

Referring once again to Fig. 1, the inner two cylinders 27, 28 of the restrictor 25 are formed to extend beyond the lower ends of the remaining cylinders 29—32 to provide a cylindrical skirt extension. The innermost cylinder 27 includes a recess 34 formed in its inner surface and the cylinder 28 is provided with a threaded outer surface 35. The cylinders 27, 28 are received within the space between the sleeve 17 and the threaded section 24 such that the restrictor is threadedly engaged with the thread surface 24 and the recess 34 of the restrictor cylinder 27 is closely received over the sleeve 17. In this manner, the restrictor 25 is securely fastened to the valve body and the input chamber 26 of the restrictor is in direct fluid communication with the flow passage 23, as discussed above.

A valve plug 36 is slidably received within the restrictor inlet chamber 26 and includes a tapered surface 37 arranged for a mating relation with the valve seat 21 of the sleeve 17. When the valve

plug 36 is in its lowermost position, as illustrated in Fig. 1, the valve will be closed and no steam will be able to escape from the pipe 10. As the plug 36 is displaced axially to, for example, the dished-line position indicated in Fig. 1, steam may flow from the pipe 10 through the passage 23 and into the inlet chamber 26. The greater the displacement of the plug 36 from the valve seat 21, the greater the number of openings 33 that will be exposed to steam. Consequently, movement of the plug 36 will control the rate of steam escape to the atmosphere. A valve stem 38 is formed integral with the plug 36 to control the axial movement of the plug 36 within the inlet chamber 26, as will appear.

In accordance with one of the features of the invention, a cylindrical balancing element 39 is slidably received within the passageway 13 such that the upper surface 40 thereof is in a spaced, confronting relation to the lower surface 41 of the valve plug. The valve stem 38 is provided with a threaded end section 42 which is received within a threaded opening 43 formed at the center of the upper surface 40 of the balancing element 39. The opposite end of the balancing element 39 is connected by a nut and threaded surface arrangement to a control rod 44 which is associated with a suitable actuator apparatus (not shown) to provide controlled, simultaneous, axial displacement for the valve plug 36 and the balancing element 39. To advantage, the opening 13 includes a section 45 of increased diameter whereby packing material 46 may be disposed between the balancing element 39 and the sides of the opening 13 to form a leak-tight seal therebetween. The packing 46 is held in place by a flanged collar 47 which is received over the balancing element 39 and secured to the end section 11 by a plurality of bolts 48.

Steam flow from the interior 14 of the valve inlet 10 enters into each of the passageway openings 12, 13, and exerts a fluid pressure on the surfaces 40, 41. The pressure acting on the surface 40 is opposite to the pressure acting on the surface 41, whereby the two pressure effects counteract each other. In accordance with one form of the invention, the cross-sectional areas of these surfaces 40, 41 are closely matched in value so that there is a complete offsetting of fluid pressure forces and the valve plug 36 is perfectly balanced. Accordingly, operation of the valve will be unaffected by unbalanced pressures. In another form of the invention (not specifically illustrated) the cross-sectional area of the surface 40 is formed to be slightly larger than the cross-sectional area of the surface 41. This arrangement will result in a slight pressure unbalance tending to urge the valve plug 36 toward the valve seat 21, thereby providing a tight valve shut-off.

Even more significantly, the balancing feature of the invention confines all high pressure fluids to within the valve body areas 10, 11. When the valve plug 36 is lifted from the valve seat 21, the high pressure fluid will flow directly into the fluid flow restrictor 25 for a controlled energy dissipation.

In accordance with another feature of the invention, the threaded connection 42, 43 between the valve stem 38 and balancing element 39 facilitates easy assembly of the device of the present invention. The valve plug 36 is received through the inlet chamber 26 of flow restrictor 25 and the balancing element 39 is received through the passageway 13. The two elements are then fastened together by rotating either or both of the plug 36 and/or balancing element 39 to threadedly engage the end 43 of the valve stem 38 within the threaded opening 42 of the balancing element 39. With such an arrangement, it is not necessary for the balancing element 39 to have a slightly smaller diameter than the fluid passage 23 in order to clear the valve seat 21 during assembly. This would be the case if the balancing element were formed integral with the valve plug 36 and valve stem 38 since such an arrangement would require the balancing element to be passed through the input chamber 26 and fluid passage 23 to assemble the device. With the two-part construction, the cross-sectional areas of the opposed surfaces 40, 41 may be precisely matched or the surface 40 may even be formed to be slightly larger in cross-sectional area than the surface 41.

Accordingly, the two-part construction for the balancing element 39 and valve plug 36 permits a perfect balancing or slight unbalancing for a tight sealing of the valve plug while providing a straightforward assembly precedure. Operation of the valve will be smooth and with minimal unbalanced pressures on the stem 38 and valve plug 36.

To advantage, a protective screen 49 may be mounted on the valve body by a plurality of bolts 50 to surround the fluid flow restrictor 25. The screen places a protective barrier around the restrictor 25 and channels the exhausted steam upwardly and away from the valve apparatus.

Instead of using the screen 49, provisions may be made to connect the valve body to the inlet of a low pressure device such as a condenser.

Thus, the present invention provides a highly advantageous high ratio pressure reducing valve. The fluid flow restrictor efficiently and safely dissipates the fluid energy of the steam, while the balancing means effectively confines the high pressure effects of the steam to within the valve body 10, 11. In accordance with the disclosure, straightforward and simplified means are utilized to fasten the restrictor to the pipe and a balanced or slightly unbalanced plug insures a smooth, reliable valve action with a tight valve shut-off.

CLAIMS

1. A high ratio pressure reducing valve, which comprises (a) high pressure fluid passage-forming means including an open end, (b) a fluid flow restrictor device including an inlet portion in fluid communication with the open end of said high pressure fluid passage-forming means, (c) said fluid flow restrictor device being mounted

ex[illegible]lly to the high pressure fluid passage-fo[illegible], means, (d) a valve plug axially movable wi[illegible]the inlet portion of the fluid flow restrictor device and operable to open and close fluid flow from the high pressure fluid passage-forming means to said inlet portion, and (e) a balancing element associated with said valve plug and including a surface in an opposed, spaced relation to the upstream, high pressure side of said valve plug whereby high pressure fluid forces acting on each of the balancing element and valve plug will tend to cancel each other out.

2. The high ratio pressure reducing valve of claim 1, further characterized by (a) said open end of the high pressure fluid passage-forming means including opposed, spaced, axially aligned passageways, (b) said fluid flow restrictor device being arranged whereby the inlet portion thereof is in fluid communication and axially aligned with one of said passageways, (c) said balancing element being slidably received in the other of said passageways.

3. The high ratio pressure-reducing valve of claim 2, further characterized by (a) a rigid valve stem interconnecting the valve plug of the inlet portion with said balancing element, and (b) actuator means associated with said balancing element to impart controlled axial movement thereto.

4. The high ratio pressure-reducing valve of claim 2, further characterized by (a) said fluid flow restrictor device comprising a series of close-fitting, rigidly fastened, concentric cylinders, (b) each of said cylinders including a plurality of fluid flow openings spaced across the surface thereof, (c) said cylinders being arranged and configured whereby each opening of each cylinder overlaps at least one opening of each contiguous cylinder to form a series of expansion chambers and restricting orifices extending radially through the cylinders, (d) said inlet portion of the fluid flow restrictor device comprising the innermost cylinder thereof, (e) said innermost cylinder being axially aligned and in fluid communication with said one passageway.

5. The high ratio pressure-reducing valve of claim 4, further characterized by said valve plug being axially movable within the innermost cylinder of said fluid flow restrictor.

6. The high ratio pressure-reducing valve of claim 5, further characterized by (a) said passage-forming means including a threaded portion, (b) at least one of said restrictor cylinders including a threaded section for engagement with the threaded portion of said passage-forming means whereby said fluid flow restrictor device is rigidly fastened to the open end of said high pressure fluid passage-forming means.

7. The high ratio pressure-reducing valve of claim 6, further characterized by (a) a cylindrical sleeve disposed within said one passageway opening in concentric relation thereto, and (b) said cylindrical sleeve including a valve seat whereby said valve plug may mate therewith to close the valve.

8. The high ratio pressure-reducing valve of claim 3, further characterized by said rigid valve stem being integrally connected to said valve plug and threadedly connected to said balancing element.

9. The high ratio pressure-reducing valve of claim 1, further characterized by the surface of said balancing element exposed to said high pressure fluid being equal in cross-sectional area to the cross-sectional area of the upstream side of said valve plug whereby there is a substantially complete balancing of high pressure forces on said valve plug.

10. The high ratio pressure-reducing valve of claim 9, further characterized by the surface of said balancing element exposed to said high pressure fluid being slightly greater in cross-sectional area than the cross-sectional area of the upstream side of said valve plug whereby there is a net force effect on the plug tending to urge said plug toward its closed position.

11. The high ratio pressure-reducing valve as herein described with reference to the accompanying drawings.

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